Final Examination

1. (Building Index) Compute TFIDF scores for all words in all documents and build an inverted index

Code and Explanation:

Mapper File for Inverted index and TFIDF:

```
#!/usr/bin/python

import os
import sys

# Read pairs as lines of input from STDIN
for line in sys.stdin:
	line = line.strip()
	words = line.split()
	for word in words:
		try:
			filename = os.environ['mapreduce_map_input_file'] ##Get the input filename
		except KeyError:
			filename = os.environ['map_input_file']
		word_file = word + "_" + filename[-7:-4] #remove last 4 char .txt and take only 100 from
/path/100.txt
		#print '%s\t%s\t%s' % (word,1,filename)
		print ("%s\t%s" %( word_file, 1))
```

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Reducer File for Inverted index and TFIDF:

```
#!/usr/bin/env python

from __future__ import division
import sys
import math

word_hits={}  ##store all word as key and list all docs contaiing the word as value


##Inverse_index dictionary:For all word in all document, key is doc and value(another dictionary) is each word in the doc along with their frequecy, tf, idf, tf_idf
##e.g., inverse_index={"doc1":{"word":[hits,freq,tf,tf_idf]}}

inverse_index={}

for line in sys.stdin:
	word_file, count = line.strip().split("\t", 1)
	word, doc = word_file.split("_")

	try:
		count = int(count)
	except ValueError:
	continue

	if word not in word_hits:
		doc_list=[]
		doc_list.append(doc)  #which doc has the word, add it to the list
		word_hits[word] = [count,doc_list]
	else:
		current_count = word_hits[word][0]
		current_doc_list=[]
		current_doc_list = word_hits[word][1]
		if doc not in current_doc_list:
			current_doc_list.append(doc)
	word_hits[word] = [current_count+1, current_doc_list]

	if doc not in inverse_index:
		word_dict={}
		word_list=[0,1,0,0]

		word_dict[word]=word_list

		inverse_index[doc]=word_dict
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```
        else:
                word_dict={}
                word_dict=inverse_index[doc]

                word_list=[0,1,0,0]

                if word not in word_dict:
                        word_dict[word]=word_list
                else:
                        current_doc_count=word_dict[word][1]
                        word_dict[word]=[0,current_doc_count+1,0,0]
                inverse_index[doc]=word_dict  ##Add inner_doc_dict to doc key as value

print '\n\n----Inverse Index-----\n\n'

for word,count_doc_list in word_hits.items():
        print '%s\t%s\t%s\n' %(word, count_doc_list[0], str(count_doc_list[1]))


print '\n\n----TF-IDF RELEVENCE SCORE---\n\n'

for doc,doc_dict in inverse_index.items():
        print '\n%s\t%s\t%s\t%s\t\t%s\t\t%s' %(doc,'HITS','FREQ','TF','IDF','TF-IDF')

        N=len(inverse_index) ##Number of documents in the directory

        ##GET Total Word in each document
    total_word_per_doc=0
    for word_count in doc_dict.values():
        total_word_per_doc+=word_count[1]

        ##for each word in a doc
        for word_key,word_value_list in doc_dict.items():

                #hits: How many doc contain the word
        hits=len(word_hits[word_key][1])

                #frequency: how many times a word appear in a doc
        frequency=word_value_list[1]

                #tf: frequency: how many times a word appear in a doc/total_word_per_doc
        tf=frequency/total_word_per_doc

                #idf: log(total number of docs/hits: how many doc contain the word))
        idf=math.log10(N/hits)
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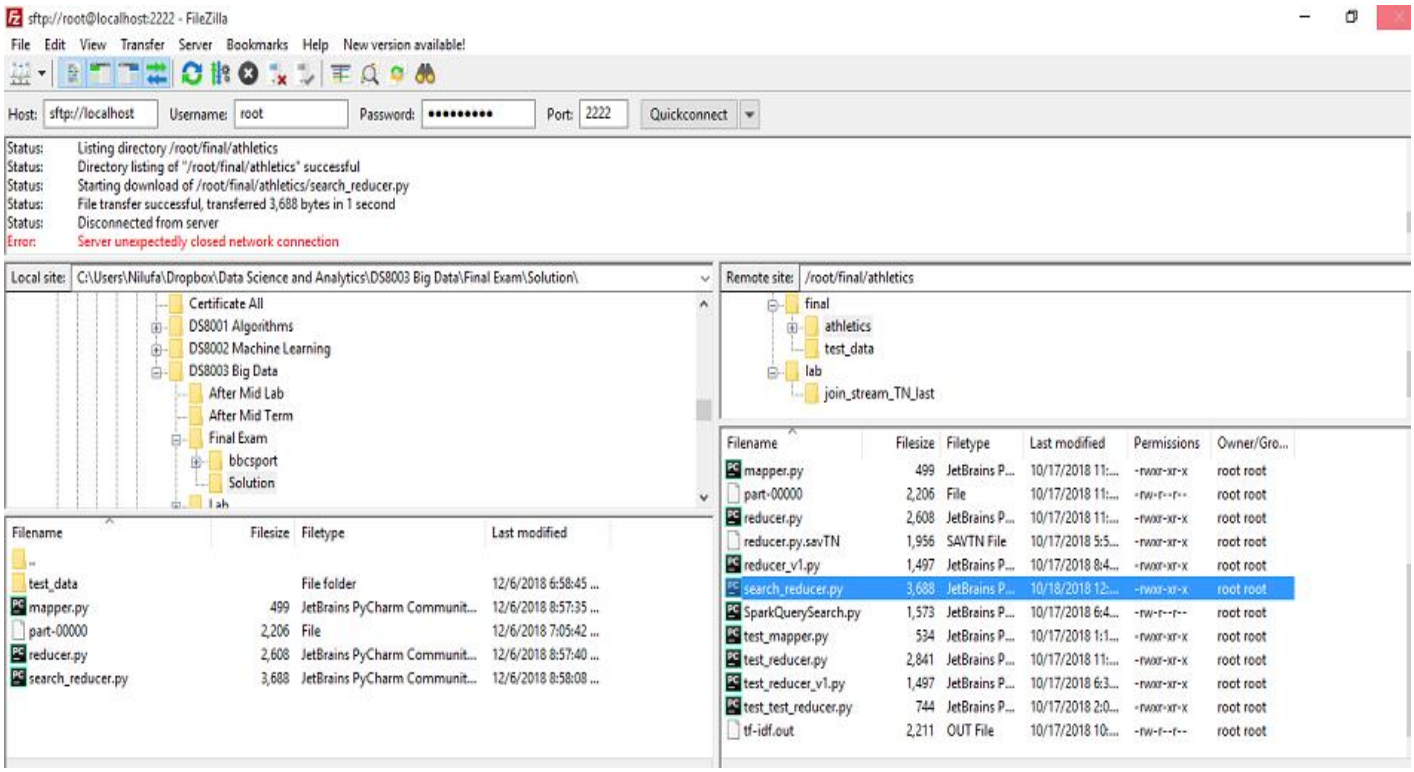
```
                    #tf_idf: Term Frequecy (TF) * idf
        tf_idf=tf*idf

                    print '%s\t%s\t%s\t%s\t%s\t%s' % (word_key,hits,frequency,tf,idf,tf_idf)
```

ScreenShot:

FileZilla file and folder



Hadoop Streaming for Question 1:

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```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help
[root@sandbox-hdp athletics]# clear

[root@sandbox-hdp athletics]# hadoop jar /usr/hdp/2.6.5.0-292/hadoop-mapreduce/hadoop-streaming-2.7.
3.2.6.5.0-292.jar -file /root/final/athletics/mapper.py -mapper mapper.py -file /root/final/athletic
s/reducer.py -reducer reducer.py -input /user/root/athletics/data/*.txt -output /user/root/final_exa
m_output_final
18/10/18 05:12:11 WARN streaming.StreamJob: -file option is deprecated, please use generic option -f
iles instead.
packageJobJar: [/root/final/athletics/mapper.py, /root/final/athletics/reducer.py] [/usr/hdp/2.6.5.0
-292/hadoop-mapreduce/hadoop-streaming-2.7.3.2.6.5.0-292.jar] /tmp/streamjob2850681100227674869.jar
tmpDir=null
18/10/18 05:12:12 INFO client.RMProxy: Connecting to ResourceManager at sandbox-hdp.hortonworks.com/
172.18.0.2:8032
18/10/18 05:12:13 INFO client.AHSProxy: Connecting to Application History server at sandbox-hdp.hort
onworks.com/172.18.0.2:10200
18/10/18 05:12:13 INFO client.RMProxy: Connecting to ResourceManager at sandbox-hdp.hortonworks.com/
172.18.0.2:8032
18/10/18 05:12:13 INFO client.AHSProxy: Connecting to Application History server at sandbox-hdp.hort
onworks.com/172.18.0.2:10200
18/10/18 05:12:14 INFO mapred.FileInputFormat: Total input paths to process : 101
18/10/18 05:12:15 INFO mapreduce.JobSubmitter: number of splits:101
18/10/18 05:12:15 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1539213858901_0238
18/10/18 05:12:16 INFO impl.YarnClientImpl: Submitted application application_1539213858901_0238
18/10/18 05:12:16 INFO mapreduce.Job: The url to track the job: http://sandbox-hdp.hortonworks.com:8
```

OutputFile for first question answer:

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help
                Reduce input records=31317
                Reduce output records=30814
                Spilled Records=62634
                Shuffled Maps =101
                Failed Shuffles=0
                Merged Map outputs=101
                GC time elapsed (ms)=127604
                CPU time spent (ms)=144510
                Physical memory (bytes) snapshot=20408516608
                Virtual memory (bytes) snapshot=197477912576
                Total committed heap usage (bytes)=11383865344
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=182744
        File Output Format Counters
                Bytes Written=1337775
18/10/18 05:19:27 INFO streaming.StreamJob: Output directory: /user/root/final_exam_output_final
[root@sandbox-hdp athletics]#
```

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Result for first question (Inverted Index):

localhost - root@sandbox-hdp:~/final/athletics VT

File Edit Setup Control Window Help

```
----Inverse Index-----


"Knowing        1       ['041']

four    21      ['015', '016', '022', '023', '026', '033', '034', '036', '041', '045', '061', '067',
 '069', '073', '079', '081', '082', '083', '093']

Olympics        22      ['015', '017', '022', '034', '036', '043', '047', '048', '050', '051', '066'
, '068', '072', '081', '082', '092', '096']

hanging 2       ['034', '066']

candidates.     1       ['043']

Ronald  2       ['058', '070']

innocence.      1       ['045']

Euro    3       ['012', '020', '073']

regional        2       ['021', '043']
```

Result for first question (TFIDF):

localhost - root@sandbox-hdp:~/final/athletics VT

File Edit Setup Control Window Help

```
----TF-IDF RELEVENCE SCORE---


098     HITS    FREQ    TF              IDF             TF-IDF
gold    37      1       0.00537634408602        0.436119649716  0.00234472929955
Union   19      1       0.00537634408602        0.72556777283   0.00390090200446
Trials  1       1       0.00537634408602        2.00432137378   0.0107759213644
indoor  30      1       0.00537634408602        0.527200119063  0.00283440924227
Maurice,"       1       1       0.00537634408602        2.00432137378   0.0107759213644
Gardener        16      1       0.00537634408602        0.800201391127  0.00430215801681
European        41      2       0.010752688172  0.391537517063  0.00421008082863
4x100m  13      1       0.00537634408602        0.890378021476  0.00478697861008
fit     10      1       0.00537634408602        1.00432137378   0.0053995772784
personal        19      1       0.00537634408602        0.72556777283   0.00390090200446
Greene, 3       1       0.00537634408602        1.52720011906   0.0082107533283
to      101     5       0.0268817204301 0.0     0.0
Championships   27      1       0.00537634408602        0.572957609624  0.00308041725604
treatment       3       1       0.00537634408602        1.52720011906   0.0082107533283
has     77      1       0.00537634408602        0.11783064861   0.000633498110807
hope    7       1       0.00537634408602        1.15922333377   0.00623238351488
his     49      3       0.0161290322581 0.314125293754  0.00506653699603
```

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Result for Result for first question Test data Streamin:

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help

[root@sandbox-hdp athletics]# hadoop jar /usr/hdp/2.6.5.0-292/hadoop-mapreduce/hadoop-streaming-2.7.
3.2.6.5.0-292.jar -file /root/final/athletics/mapper.py -mapper mapper.py -file /root/final/athletic
s/reducer.py -reducer reducer.py -input /user/root/test_data/*.txt -output /user/root/final_exam_out
put_test_Final
18/10/18 05:31:09 WARN streaming.StreamJob: -file option is deprecated, please use generic option -f
iles instead.
packageJobJar: [/root/final/athletics/mapper.py, /root/final/athletics/reducer.py] [/usr/hdp/2.6.5.0
-292/hadoop-mapreduce/hadoop-streaming-2.7.3.2.6.5.0-292.jar] /tmp/streamjob5991646472179977972.jar
tmpDir=null
18/10/18 05:31:12 INFO client.RMProxy: Connecting to ResourceManager at sandbox-hdp.hortonworks.com/
172.18.0.2:8032
18/10/18 05:31:13 INFO client.AHSProxy: Connecting to Application History server at sandbox-hdp.hort
onworks.com/172.18.0.2:10200
18/10/18 05:31:13 INFO client.RMProxy: Connecting to ResourceManager at sandbox-hdp.hortonworks.com/
172.18.0.2:8032
18/10/18 05:31:13 INFO client.AHSProxy: Connecting to Application History server at sandbox-hdp.hort
onworks.com/172.18.0.2:10200
18/10/18 05:31:14 INFO mapred.FileInputFormat: Total input paths to process : 5
18/10/18 05:31:14 INFO mapreduce.JobSubmitter: number of splits:5
18/10/18 05:31:15 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1539213858901_0239
18/10/18 05:31:16 INFO impl.YarnClientImpl: Submitted application application_1539213858901_0239
18/10/18 05:31:16 INFO mapreduce.Job: The url to track the job: http://sandbox-hdp.hortonworks.com:8
088/proxy/application_1539213858901_0239/
```

Result for first question Test data Streaming Output file:

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help
                Reduce output records=96
                Spilled Records=68
                Shuffled Maps =5
                Failed Shuffles=0
                Merged Map outputs=5
                GC time elapsed (ms)=3547
                CPU time spent (ms)=7760
                Physical memory (bytes) snapshot=1147351040
                Virtual memory (bytes) snapshot=11640664064
                Total committed heap usage (bytes)=610271232
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=169
        File Output Format Counters
                Bytes Written=2206
18/10/18 05:31:55 INFO streaming.StreamJob: Output directory: /user/root/final_exam_output_test_Fina
l
```

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Result for first question Test Data (Inverted Index):

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help

[root@sandbox-hdp athletics]# hadoop fs -cat /user/root/final_exam_output_test_Final/part-00000

----Inverse Index-----

is      3       ['001', '002', '003']

weather 1       ['004']

data    2       ['001', '003']

there   1       ['002']

hadoop  2       ['001']

how     1       ['004']

does    1       ['004']

storm   2       ['001', '002']

new     1       ['003']
```

Result for first question Test Data (TFIDF):

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help

----TF-IDF RELEVENCE SCORE---

003     HITS    FREQ    TF              IDF             TF-IDF
new     1       1       0.2     0.698970004336  0.139794000867
is      3       1       0.2     0.221848749616  0.0443697499233
oil     1       1       0.2     0.698970004336  0.139794000867
data    2       1       0.2     0.397940008672  0.0795880017344
the     3       1       0.2     0.221848749616  0.0443697499233

002     HITS    FREQ    TF              IDF             TF-IDF
a       1       1       0.125   0.698970004336  0.087371250542
this    2       1       0.125   0.397940008672  0.049742501084
big     2       1       0.125   0.397940008672  0.049742501084
is      3       1       0.125   0.221848749616  0.027731093702
there   1       1       0.125   0.698970004336  0.087371250542
storm   2       1       0.125   0.397940008672  0.049742501084
coming  1       1       0.125   0.698970004336  0.087371250542
weekend 2       1       0.125   0.397940008672  0.049742501084

001     HITS    FREQ    TF              IDF             TF-IDF
```

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Summary section: I've have created a test data same as our class lecture example. My test data given below:

001.txt file- hadoop is taking the big data world by storm big hadoop
002.txt file- there is a big storm coming this weekend
003.txt file- data is the new oil
004.txt file- how does the weather look like this weekend
005.txt file- hello world

I've checked my implementation (code) first from my test data. After that, I've worked on BBC articles (Athletics). I've set my first question answer based on lecture slide 16 example [week 11 lecture slide 16].

- My system will provide a Inverted index and TFIDF for BBC articles (Athletics
- I've worked with Hadoop MapReduce. Hadoop Mapreduce can access structured and unstructured data as well which is good.
- I think it's good. Hadoop Mapreduce support for numerous languages (java straming, python straming) that can be used for data processing and storage.

Why I chose Mapreduce, Compare with other tools: Hadoop Mapreduce support for numerous languages (java straming, python straming) for large data processing which is really good I think. However, I've also plan to work on Python Spark with same dataset.

2. (Search) Given a new query (one or more words) and a value N, retrieve the top N matching documents with a score (use TFIDF scores to retrieve the matching documents)

Code and Explanation:

Mapper File for Search and TopN matching:

```
#!/usr/bin/python

import os
import sys

# Read pairs as lines of input from STDIN
for line in sys.stdin:
	line = line.strip()
	words = line.split()
	for word in words:
		try:
			filename = os.environ['mapreduce_map_input_file'] ##Get the input filename
		except KeyError:
			filename = os.environ['map_input_file']
		word_file = word + "_" + filename[-7:-4] #remove last 4 char .txt and take only 100 from
```

```
/path/100.txt
                        #print '%s\t%s\t%s' % (word,1,filename)
                        print ("%s\t%s" %( word_file, 1))
```

Reducer File for Search and TopN matching:

```
#!/usr/bin/env python

from __future__ import division
import sys
import math

word_hits={}  ##store all word as key and list all docs contaiing the word as value


##Inerse_index dictionary:For all word in all document, key is doc and value(another dictionary) is each word in the doc along with their frequecy, tf, idf, tf_idf
##e.g., inverse_index={"doc1":{"word":[hits,freq,tf,tf_idf]}}

inverse_index={}

query="the big data"
topN=3

for line in sys.stdin:
        word_file, count = line.strip().split("\t", 1)
        word, doc = word_file.split("_")

        try:
                count = int(count)
        except ValueError:
        continue

        if word not in word_hits:
                doc_list=[]
                doc_list.append(doc)  #which doc has the word, add it to the list
                word_hits[word] = [count,doc_list]
        else:
                current_count = word_hits[word][0]
                current_doc_list=[]
                current_doc_list = word_hits[word][1]
                if doc not in current_doc_list:
                        current_doc_list.append(doc)
        word_hits[word] = [current_count+1, current_doc_list]

        if doc not in inverse_index:
```

```
                word_dict={}
                word_list=[0,1,0,0]

                word_dict[word]=word_list

                inverse_index[doc]=word_dict

        else:
                word_dict={}
                word_dict=inverse_index[doc]

                word_list=[0,1,0,0]

                if word not in word_dict:
                        word_dict[word]=word_list
                else:
                        current_doc_count=word_dict[word][1]
                        word_dict[word]=[0,current_doc_count+1,0,0]
                inverse_index[doc]=word_dict  ##Add inner_doc_dict to doc key as value


##all_tf_idf_dict={"doc1":{"word1":tfidf}}
all_tf_idf_dict={}

for doc,doc_dict in inverse_index.items():
#       print '\n%s\t%s\t%s\t%s\t\t%s\t\t%s' %(doc,'HITS','FREQ','TF','IDF','TF-IDF')

        N=len(inverse_index) ##Number of documents in the directory

        ##GET Total Word in each document
    total_word_per_doc=0
    for word_count in doc_dict.values():
        total_word_per_doc+=word_count[1]

        each_doc_dict={}

        ##for each word in a doc
        for word_key,word_value_list in doc_dict.items():

                #hits: How many doc contain the word
        hits=len(word_hits[word_key][1])

                #frequency: how many times a word appear in a doc
        frequency=word_value_list[1]

                #tf: frequency: how many times a word appear in a doc/total_word_per_doc
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```
            tf=frequency/total_word_per_doc

                        #idf: log(total number of docs/hits: how many doc contain the word))
            idf=math.log10(N/hits)

                        #tf_idf: Term Frequecy (TF) * idf
            tf_idf=tf*idf

                        #tf_idf_list=[]
                        #tf_idf_list.append(word_key)  #load the word in a doc
                        #tf_idf_list.append(tf_idf)    #load tf_idf for the word in a doc

                        each_doc_dict[word_key]=tf_idf

                        #print '%s\t%s\n' % (word_key,each_doc_dict[word_key])
            all_tf_idf_dict[doc] = each_doc_dict


###Print all word and their tf-idf
#for key,value in all_tf_idf_dict.items():
            #print '%s\t%s\n' %(key,'TF-IDF')
#           for w,tfidf in value.items():
                        #print '%s\t%s\n' %(w,tfidf)

##Search

query_word_list=query.split()

score_dict={}

for dd,vv in all_tf_idf_dict.items():
            score_in_doc=0
            score_in_doc_sum=0
            count=0
            for query_word in query_word_list:
                        #get_docs_list=word_hits[query_word][1]
                        #print '%s\t%s\n' %(query_word,str(get_docs_list))

                        #for d in get_docs_list:
                        if query_word in vv:
                                    score_in_doc_sum+=float(vv[query_word])
                                    count+=1
            score_in_doc=score_in_doc_sum*(count/len(query_word_list))
            score_dict[dd]=score_in_doc

#print "\n\nScore\n\n"
```

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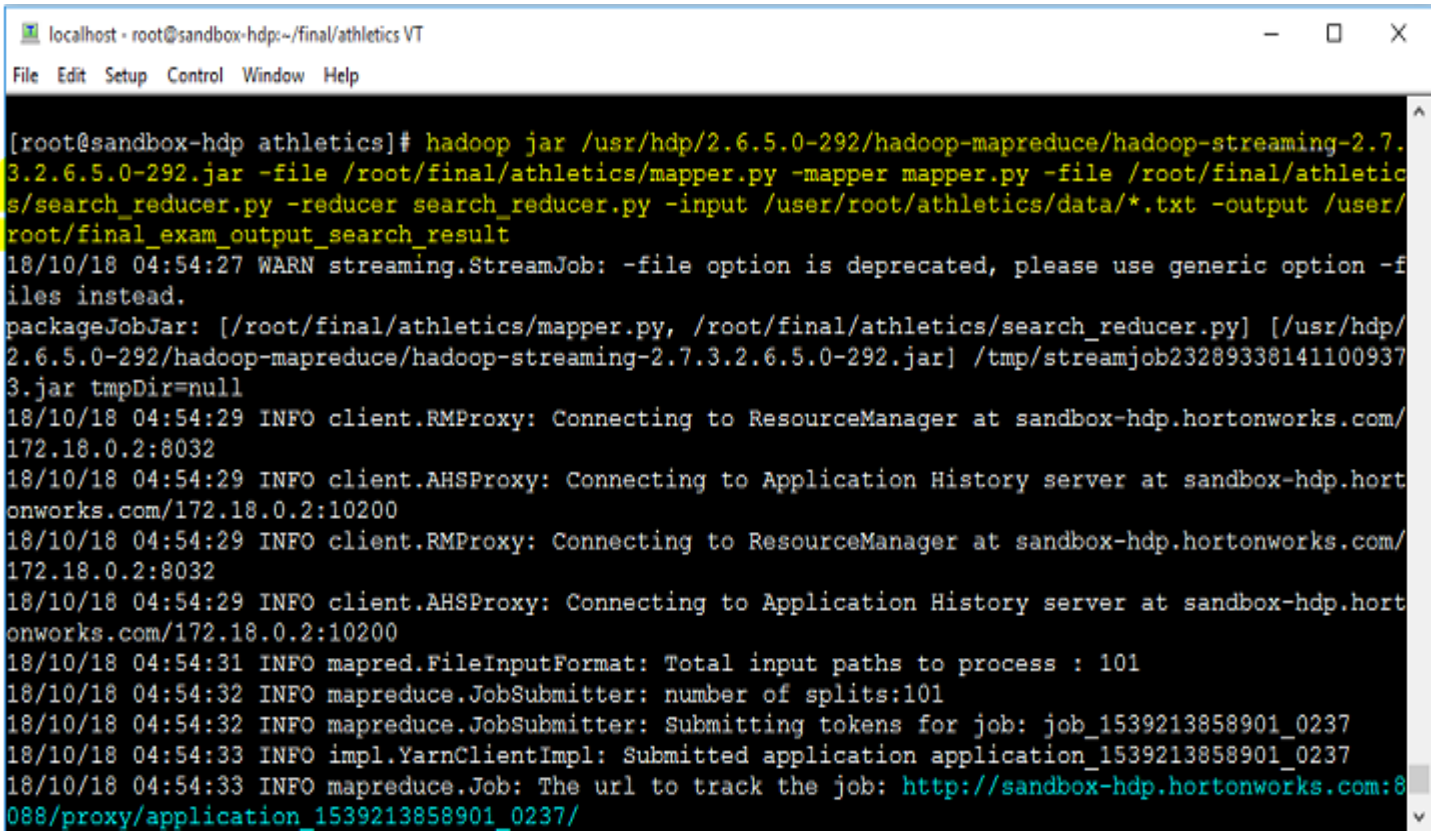
```
#for dc,sc in score_dict.items():
#           print '%s\t%s' %(dc,str(sc))

print 'Top %s Matching Document\n\n' %(topN)
print '%s\t\t%s\n' %("DOCNAME","SCORE")

c=0
for key, v2 in sorted(score_dict.iteritems(), key=lambda (k,v): (v,k), reverse=True):
            if c < topN:
                        print '%s\t%s\n' % (key, v2)

            c+=1
```

Hadoop Streaming for Question 2:



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Streaming Output file :

```
localhost - root@sandbox-hdp:~/final/athletics VT
File  Edit  Setup  Control  Window  Help
                Reduce output records=11
                Spilled Records=62634
                Shuffled Maps =101
                Failed Shuffles=0
                Merged Map outputs=101
                GC time elapsed (ms)=119970
                CPU time spent (ms)=145650
                Physical memory (bytes) snapshot=19908669440
                Virtual memory (bytes) snapshot=197461716992
                Total committed heap usage (bytes)=11382292480
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=182744
        File Output Format Counters
                Bytes Written=115
18/10/18 05:02:20 INFO streaming.StreamJob: Output directory: /user/root/final_exam_output_search_re
sult
```

Search result from Documents and Top N:

```
[root@sandbox-hdp athletics]# hadoop fs -cat /user/root/final_exam_output_search_result/part-00000
Top 3 Matching Document


DOCNAME         SCORE

031     0.00482794880158

039     0.00409387471479

059     0.00308393205387
```

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Summary section: For the second question answer, I've used TFIDF to find Relevant Search results. I've already find out TFIDF scorers in first question. So, I can use here TFIDF scores from the previous file. However, for the first question answer, I've saved my output file (Inverted index and TFIDF) in one file. So, here I calculate again TFIDF scores. Here is my searching query and TopN,

query="the big data"
topN=3

- I've Searched **"the big data"** in all text file
- I've used TFIDF score to get top N matching documents from text file

3. Additionally, if the system can do it in real-time or near real-time

Answer: No, the system can't do it real time. I've implemented my system in single processor. If I want to do it in real time I need to work with multiple processors in a cluster.